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HEADQUARTERS  
U.S. ARMY AVIATION TEST ACTIVITY  
Edwards Air Force Base, California 93523

STEAV-OP

SUBJECT: Letter Report of Preliminary Pilot Qualitative Evaluation  
of the XV-5A Research Aircraft

TO: Commanding Officer  
U. S. Army Aviation Materiel Laboratories  
ATTN: OSMFE-AA  
Fort Eustis, Virginia 23604

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NOV 1 1966

1. References:

a. Contract No. DA44-177-TC-715, "Lift-Fan Flight Research Aircraft Program," Department of the Army, 10 November 1961.

b. "Plan of Test for Engineering Research and Evaluation Test of the XV-5A Lift-Fan Aircraft," U. S. Army Aviation Test Activity (USAAVNTA), USAAVNTA Project No. 62-72, December 1964.

c. Pilot Techniques for Stability and Control Testing, C. B. Doyle, Lt Colonel, USMC., Test Pilot Training Division, Naval Air Test Center, as revised summer 1958.

d. U. S. Army XV-5A Accident Report, Edwards Air Force Base, California (27 April 1965), U. S. Army Aviation Materiel Laboratories (USAAVNMLABS), Fort Eustis, Virginia.

2. Authority:

a. Letter, ANSTE-BG, Hq, U. S. Army Test and Evaluation Command, (USATECOM), 12 March 1965, subject: "Test Directive for Military Potential Test of the Lift-Fan Propulsion System Concept Installed in the XV-5A Aircraft, USATECOM Project-Task No. 4-5-1220-01."

b. Letter, OSMFE-AA, USAAVNMLABS, 15 September 1965, subject: "Interim Pilot Report on XV-5A Phase II Flight Test," and 1st Indorsement, ANSTE-BG, Hq, USATECOM, 28 September 1965, subject: "Interim Pilot Report on XV-5A Phase II Flight Test."

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### 3. Objectives:

The primary objective of these tests was to investigate those aircraft characteristics directly influenced by the Lift-Fan concept. This report contains the results of the preliminary pilot evaluation of the XV-5A aircraft during the stability and control portion of the U. S. Army flight test program.

### 4. Responsibilities:

The USAAVNMLABS was assigned to provide a Program Manager's representative and to have technical control and cognizance of the overall test program.

The USAAVNTA was assigned to conduct the engineering flight test program, to include the preparation and coordination of the plan of test, coordination of test execution and preparation of the required reports.

### 5. Description of Materiel:

The XV-5A is a twin-engine, tri-fan, tricycle-gear, mid-wing, turbojet-powered research aircraft. The aircraft is capable of both vertical and conventional flight. The crew stations consist of a single cockpit with side-by-side seating for pilot and observer. The test aircraft was modified by the removal of the observer's seat to provide instrumentation area. Two J-85-5B turbojet engines, rated individually at 2500 pounds thrust for standard sea-level conditions, power the XV-5A. Two diverter valve actuators are provided for diverting the engines' exhaust gases through cross-over ducts to drive the two wing fans and single nose fan during fan-powered flight. A three-view illustration of the XV-5A and a brief description of its general characteristics are presented in Inclosure 1. The aircraft's control systems are described in Inclosure 2. Two aircraft, Army S/N 62-4505 and S/N 62-4506, the only models of the XV-5A, were tested.

### 6. Background:

a. On 10 November 1961, the Department of the Army initiated a contract (Reference 1.a) for a contractor conducted development and flight research program of two aircraft utilizing the lift-fan propulsion system. Specific objectives of the program were to determine and evaluate the characteristics of lift-fan-powered flight and to investigate the characteristics observed during flight at high subsonic speeds. -- Phase I Program.

b. On 26 January 1965, the described initial test phase was completed. The two XV-5A aircraft were accepted by the Department of Army so that continued flight testing could be conducted by Army personnel. The planning details of the Army flight test program are contained in Reference 1.b. The two XV-5A aircraft were assigned to USAAVNMLABS for aircraft and engine performance testing at Edwards Air Force Base by USAAVNTA and USAAVNMLABS personnel. -- Phase II Program.

#### 7. Scope of Tests:

a. The XV-5A was evaluated with respect to its primary mission as a lift-fan research aircraft within the flight limitations shown in Inclosure 5. These tests were accomplished in accordance with the applicable standard procedures set forth in the Plan for Engineering Research and Evaluation Test of the XV-5A Lift-Fan Aircraft (Reference 1.b).

b. Tests were conducted at Edwards Air Force Base, California, during the period 28 January 1965 through 30 June 1965. Fifty-two flights, totaling 24:15 hours, were flown during these tests by three U. S. Army Engineering Test Pilots. A summary of individual pilot participation in this evaluation is presented in Inclosure 8. A description of test configurations is presented in Inclosure 7. Gross weight and center-of-gravity (C.G.) information are presented in Inclosure 4.

#### c. Chronology:

The chronology of the testing was as follows:

(a) Project aircraft accepted by U. S. Army	26 Jan 65
(b) Project flying commenced	28 Jan 65
(c) XV-5A, S/N 62-4506, destroyed in crash*	27 Apr 65
(d) Stability and control portion of testing completed	30 Jun 65
(e) Pilot Evaluation Report submitted	1 Nov 65
(f) Performance portion of testing commenced	22 Jul 65

\*See Ref. 1.d for details.

## 8. Methods of Test:

Test methods were in accordance with those of References 1.b and 1.c. Test instrumentation was as specified in Inclosure 3.

## 9. Findings:

### a. Summary:

(1) The flying qualities of the XV-5A observed during this evaluation were suitable for accomplishment of the primary mission of the XV-5A as a research aircraft. Five deficiencies were observed for which corrective action is mandatory for follow-on XV-5 aircraft:

- (a) Cockpit temperature control (Paragraph 9.b(1)).
- (b) Ground handling characteristics (Paragraph 9.d.(1)).
- (c) Vertical takeoff and landing characteristics (Paragraphs 9.f.(1), (2), (3)).
- (d) Wing lift-fan cavity heating characteristic (Paragraph 9.h(2)).
- (e) Ten-minute limitation fan-powered flight (Paragraph 9.i(4)).

(2) In addition, correction of the following eleven shortcomings is desirable for follow-on XV-5 aircraft:

- (a) Cockpit instrument and switch locations (Paragraphs 9.b(2), (3), (4)).
- (b) Cockpit downward and aft vision (Paragraphs 9.b (5), 9.f(3)).
- (c) Canopy release mechanism (Paragraph 9.b(6)).
- (d) Lack of parking brake (Paragraph 9.d(2)).
- (e) Conventional and vertical crosswind landing characteristics (Paragraphs 9.e(3), 9.f(3)).
- (f) Engine overtemp characteristics (Paragraph 9.h(1)).

(g) Lift-fan air re-ingestion characteristics in close proximity to the ground (Paragraph 9.i(3)).

(h) Lift-fan overspeed characteristics (Paragraph 9.i(1)).

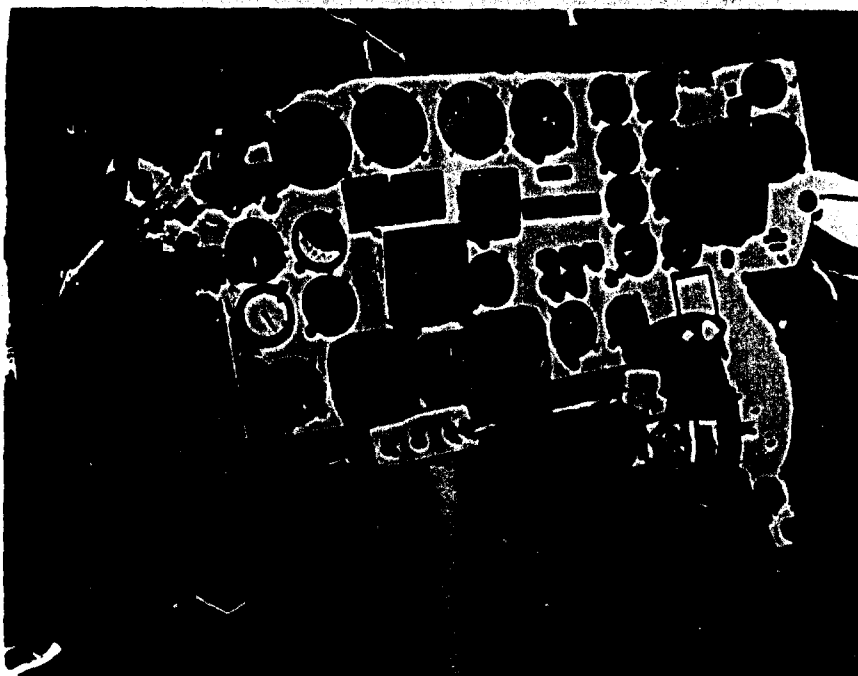
(i) Lack of speed brakes (Paragraph 9.j(1)).

(j) Longitudinal trimmability characteristics during conventional and fan-powered flight (Paragraphs 9.k(2), 9.k(3)).

(k) Lateral "gust sensitivity" in preconversion (PC) configuration (Paragraph 9.l(7)).

(3) An overall pilot opinion rating (see Inclosure 9) of 4 was assigned to the flying qualities of the XV-5A aircraft.

b. Cockpit Evaluation:



XV-5A Cockpit

Figure 1

(1) The cockpit area was large and provided the pilot with ample space. In-flight cockpit temperature control was unsatisfactory. Ventilation was achieved by small vents along the canopy periphery. These vents were inadequate cooling devices at lower altitudes and, due to the pilot's inability to close them, unsatisfactory during high-altitude flights. Correction of this deficiency is mandatory for follow-on XV-5A aircraft.

(2) In-flight switches and controls were within easy reach of the pilot except for the oxygen diluter valve and oxygen quantity gage which were to the right rear of the pilot. Both the diluter valve and quantity gage should be repositioned for easy pilot access. Visual check of the mode select switch and electrical system switch, positioned on the lift stick, required total pilot attention. These two switches should be repositioned to alleviate this situation. The spin drag parachute release handle partially obscured the master caution warning light and should also be repositioned. These shortcomings should be corrected in future models.

(3) The rate of climb, low airspeed indicator and high airspeed indicator were positioned ineffectively for pilot scanning. While obtaining data during fan-powered flight, primary instruments were: angle of attack, rate of climb and low airspeed indicator. An improvement in the instrument presentation, therefore, would be to locate these instruments from the pilot's left to right along the top of the instrument panel: angle of attack, rate of climb, low airspeed indicator and high airspeed indicator (see Inclosure 6). This change is desirable to improve the suitability of the XV-5A to perform its primary mission.

(4) Further instrumentation recommendations are to offset the right side of the instrument panel so that pilot vision is normal to the engine and fan instruments located on the right portion of the instrument panel. The following changes, also shown in Inclosure 6, were recommended:

Instrument	Relocated to Existing Position Occupied By:
Nose-Fan Tachometer	Left J-85-5B EGT Gage
Wing-Fan Tachometer	Right J-85-5B EGT Gage
Left J-85-5B EGT Gage	Left J-85-5B Fuel Flow Gage
Right J-85-5B EGT Gage	Right J-85-5B Fuel Flow Gage
Left J-85-5B Fuel Flow Gage	Fuel Quantity Gage
Right J-85-5B Fuel Flow Gage	J-85-5B Oil Pressure Gage
Fuel Quantity Gage	Nose-Fan Tachometer
Oil Pressure Gage	Clock
Clock	Remove

Accomplishment of the described changes would provide the pilot with an excellent density of engine and fan instrumentation.

(5) Fields of view forward and sideward were good. During hover operations, downward and aft vision were restricted. Although satisfactory for purposes of this evaluation, the restricted hover vision would be a significant shortcoming in an operational XV-5 aircraft.

(6) The canopy release mechanism provided no satisfactory "vent" position for use during ground operations. In addition, no positive canopy lock indication was available to the pilot. Correction of these shortcomings is desirable for follow-on XV-5 aircraft.

c. Engine Start and Preflight Checks:

The preflight aircraft exterior check consisted of a walk-around inspection that required approximately 5 minutes. The engines were started on the ground by use of an external air impingement starter driven by compressed air from a mobile gas turbine compressor. Engine starting procedure was simple and idle RPM was obtained in less than 30 seconds after start initiation. After engine start, the ground checks were extensive for flights that entailed in-flight conversions and/or reconversions between conventional and fan-powered flight. The approximate 10 minutes required to accomplish these ground checks was not considered to be excessive for a research aircraft. The lack of a parking brake made these checks fatiguing.

d. Ground Handling:

(1) The light-duty brakes and narrow main gear track (8.39 feet wheel to wheel) caused prolonged taxiing to be precarious. The use of thrust spoilers to reduce residual thrust as an additional braking technique did not satisfactorily alleviate this problem. On numerous occasions the test program was delayed due to brake overheating and failures. These results were unsatisfactory and detracted from the ability of the XV-5A to perform its primary mission. It is mandatory that any follow-on XV-5 aircraft be modified to correct this deficiency.

(2) The lack of a parking brake resulted in pilot discomfort and fatigue during the previously discussed extensive ground checks. Correction of this shortcoming is desirable for all follow-on XV-5 aircraft.

e. Conventional Takeoff and Landing:

(1) Qualitatively the conventional takeoff and landing characteristics observed during this evaluation enhanced the flying qualities of the XV-5A. Two flap settings, zero percent and 25 percent, were investigated at various horizontal stabilizer positions. Of the horizontal stabilizer positions investigated, -3.5 degrees and -2 degrees were optimum for takeoff with 25 percent and zero percent flaps respectively. Approximate takeoff performance data observed for these configurations are shown in Table 1:

TABLE 1				
J-85 RPM: 100 PERCENT TAKEOFF GROSS WEIGHT: 11,200 LBS PRESSURE ALTITUDE ( $H_p$ ): 2350 FT				
Flap	Horizontal Stabilizer deg	Runway Temperature deg F	Wind deg/kt*	Runway Distance ft
0	-2	57	230/8	2500
25	-3.5	60	Calm	1700

\* Runway heading: 220 deg.

The zero percent flap takeoff was the more desirable of the two flap configurations investigated. With a zero percent flap setting the pilot was able to rotate the aircraft 15 knots indicated airspeed (KIAS) prior to the approximate lift-off speed of 125 KIAS. This procedure allowed a smooth transition from takeoff roll to takeoff climb. With 25 percent flaps extended, aircraft rotation and lift-off occurred simultaneously at approximately 110 KIAS. The stick forces required to initiate rotation were high (approximately 25 pounds) during rotation but returned to trim at lift-off.

(2) Directional control during takeoff ground run was effortless. Rudder effectiveness was noted at approximately 40 KIAS and aileron effectiveness was noted at 80 KIAS. During early flights there was a tendency toward pilot-induced lateral oscillations during climbout. As flight experience in the test aircraft was obtained, this lateral over-control tendency was easily eliminated. A pilot opinion rating of 2-1/2 was assigned to the conventional takeoff characteristics observed during this evaluation.

(3) The conventional landing characteristics observed without crosswind or turbulence were satisfactory. The narrow-track landing-gear geometry, low-power brakes and large aircraft side area all contributed to the poor crosswind landing characteristics exhibited. Crosswind landings were characterized by large compensating bank angles into the wind required to maintain desired ground track. Immediately after touchdown the aircraft tended to turn downwind; this required total pilot attention to correct with rudder and brake control. These results were undesirable and would severely limit the conventional operational capabilities of any follow-on XV-5 model aircraft. With 25 percent flaps, normal landing approaches were flown at an approximately 12-degree angle of attack (130 KIAS) and 85 percent J-85-5B engine RPM. Under these conditions, touchdown occurred at a 15-degree angle of attack (110 KIAS). The aircraft was firm on landing and exhibited no tendency to bounce or float during touchdown. Aerodynamic braking was possible by holding the nosewheel off the ground until approximately 85 KIAS when insufficient elevator effectiveness was available to hold the nose-wheel off. "Wave-off" characteristics from normal approaches were excellent with no loss of altitude required. A pilot opinion rating of 3-1/2 was assigned to the conventional landing characteristics of the XV-5A.

f. Vertical Takeoff and Landing:

(1) The vertical takeoff and landing characteristics in close proximity to the ground (zero-foot to 10-foot wheel heights), discussed in the following two paragraphs, comprised the weakest portion of the flying qualities of the XV-5A and detracted from the aircraft's ability to accomplish its primary research mission. A pilot opinion rating of 5-1/2 was assigned to these characteristics.

(2) During vertical takeoffs, immediately after main gear lift-off, the test aircraft exhibited moderate disturbances that caused the pilot to remain in this region a minimum time. The intensity of the disturbances decreased as wheel height increased and was completely eliminated at a wheel height of approximately 10 feet. Due to the severity of the disturbances the ability to perform precise tasks in the zero-foot to 10-foot wheel-height area was questionable. This result dictates that all prolonged hover operations be conducted at wheel heights above 10 feet, where a single engine failure would result in aircraft damage and possible pilot injury. Correction of this deficiency is mandatory for follow-on XV-5 aircraft.

(3) Precise vertical landings were limited by the disturbances mentioned in Paragraph 2.b(2). Prior to a vertical landing the pilot was forced to select the proposed touchdown spot at a wheel height above 10 feet and then devote all his attention to lowering the aircraft through the region of increasing disturbance to the pre-selected landing spot. These results were undesirable. Due to the narrow main landing gear and large aircraft side area, the possibility of a lateral "tip-over" due to a sideward translation at touchdown was always present during hover operations in wind. To reduce this risk, hover operations were restricted to winds of less than 5 knots. Restricted downward visibility and landing gear location prevented the pilot from obtaining precise wheel height information in close proximity to the ground. This characteristic caused the pilot to "hunt" for the ground and often resulted in an undesirable "bouncy" landing due to the reluctance of the pilot to reduce power until a "wheels-on-the-ground" condition was certain. "Wave-off" characteristics for lift-to-weight ratios greater than 1.1 were excellent and were performed with no loss of height.

g. Hover (Above 10-Foot Wheel Height):

At wheel heights above 10 feet the XV-5A was heavily damped about all three axes for the test condition stability augmentation system (SAS) settings. Results of dynamic steps and pulses about the three axes showed the SAS to be a very effective system. It is recommended that future testing be conducted for SAS optimization. Some lateral-directional coupling was observed; however, no objectionable coupling characteristics were experienced. These results were pleasant to the pilot and provided a "steady platform" at the stationary hover. Height control with throttle manipulation resulted in pilot-induced vertical oscillations due to the slow power response. Height control with lift-stick manipulations, although not as responsive as in a gas-turbine-powered helicopter (UH-1), was satisfactory. During hovering flight, control stick "pressure forces" resulted in immediate aircraft response in the correct direction. Control stick displacements in all cases were negligible. Control harmony was excellent and enhanced the aircraft's flying qualities. The XV-5A was extremely sensitive to crosswind; a 2-3 mph crosswind caused the aircraft to yaw downwind. During 15-mph sideward flight this characteristic was emphatically noted by the increasing requirement to apply "lower" rudder as airspeed increased. No objectionable aircraft attitudes were observed during either 15-mph sideward flight or 10-mph rearward flight. A pilot opinion rating of 3-1/2 was assigned to the XV-5A hover characteristics above a 10-foot wheel height.

#### h. Engine Operating Characteristics:

(1) The J-85-5B operating characteristics (starting, stopping, compressor stall tendencies, etc.) observed during this evaluation were excellent except for high operating temperatures noted during low-speed flight in fan-powered (FP) configuration. On three occasions over-temp (680 degrees Centigrade) conditions were encountered and required a power reduction to correct. During conventional flight engine accelerations from flight-idle to maximum power required approximately 5 seconds with no overtemping tendencies noted.

(2) An allied problem caused by J-85-5B heat dissipation was noted during conventional flight. The right wing-fan cavity area reached its overtemp condition (120 degrees Centigrade) at approximately 96 percent J-85-5B RPM, thereby constituting a performance limitation. Correction of this deficiency is mandatory for follow-on XV-5 aircraft.

(3) At or below a lift-to-weight ratio of approximately 1.1, the test aircraft exhibited undesirable engine re-ingestion characteristics while in close proximity to the ground. This re-use of low-energy air was noted on numerous occasions during vertical takeoffs. From the cockpit this condition was noted by an apparent "hang-up" with little or no response to increased power application. To continue takeoff climb after encountering re-ingestion, a satisfactory technique was to change aircraft attitude in pitch or yaw. This technique altered the air flow from the re-ingested pattern to a normal pattern and allowed a vertical climb. Correction of this re-ingestion shortcoming, to be investigated quantitatively during the ensuing performance portion of the XV-5A evaluation, is desirable for follow-on XV-5 aircraft.

#### i. Lift-Fan Operating Characteristics:

(1) Lift-fan overspeed characteristics were observed during high-speed flight (75 KIAS - 95 KIAS) in FP configuration. These characteristics were undesirable and necessitated an automatic "power cutback" system which reduced J-85-5B RPM to approximately 97 percent when lift-fan over-speed limits (wing fan: 103 percent, pitch fan: 110 percent) were exceeded. Although no objectionable flight characteristics were observed following automatic "power cutback," normal pilot reaction was to avoid the automatic cutback.

(2) As a result of the lift-fan characteristics of increasing RPM with increased airspeed and/or angle of attack ( $\alpha$ )

the pilot was continually adjusting power with throttle manipulation to maintain a fixed fan RPM during an airspeed change. These results detracted from the suitability of the XV-5A to perform its primary research mission. Correction of this shortcoming for follow-on XV-5 model aircraft is desirable.

(3) The lift-fan acceleration characteristics were excellent. Approximately 2 seconds were required to accelerate the wing-fan and nose-fan RPM from zero percent RPM to 100 percent RPM after diverter valve actuation.

(4) The airframe structural heating characteristic in FP configuration limited flight duration to 10 minutes. This short allowable flight duration was achieved only after installation of a heat shield which compromised the aircraft's conventional flight performance. The heat shield did not permit retraction of the landing gear. These results were unsatisfactory and detracted from the suitability of the test aircraft to perform its primary research mission. Correction of this deficiency is mandatory for follow-on XV-5 model aircraft.

j. Conversion:

(1) The conventional-to-fan-powered-flight conversion characteristics enhanced the XV-5A's flying qualities. Conversions were conducted in level flight at the following conditions: J-85-5B RPM (97 percent - 100 percent), density altitude (4500 feet - 8500 feet), and airspeed (95 KIAS - 105 KIAS). All conversions were characterized by a mild pitch-over (from +13 degrees  $\alpha$  to +5 degrees  $\alpha$ ) which required approximately 15 pounds of aft stick force to arrest without an altitude loss. A sensation of deceleration, similar to that following the extension of speed brakes in a conventional aircraft, was the most prominent "cockpit cue" of conversion. Additional cockpit cues were: horizontal stabilizer visual and aural signals' denoting the programmed movement of the stabilizer to the 10-degree leading edge up position, visual signal's denoting diverter valve in the lift-fan position and increased noise level due to the three fans' coming up to speed. The increased noise level was of such magnitude that radio communications were impaired unless the pilot wore a snugly fitted flying helmet and oxygen face mask. Total time required for the conversion was approximately 3 seconds. The major changes that occurred during conversions are shown in Table 2:

TABLE 2

	Before (Zero Time)	After (Zero Time +3 sec)
J-85-5B RPM	97% - 100%	100% +
Wing-Fan RPM	Zero %	100% +
Nose-Fan RPM	Zero %	100% +
Horizontal Stabilizer	-5° to -3° Leading Edge Down	+10° Leading Edge Up
Angle of Attack	+12° $\alpha$ to +15° $\alpha$	Zero° $\alpha$ to +5° $\alpha$
Wing-Fan Doors	Closed	Open
Airspeed	95 KIAS to 105 KIAS	80 KIAS to 90 KIAS
Configuration	Pre-conversion	Fan-powered

The pertinent components that remained unchanged are shown in Table 3:

TABLE 3

	Before (Zero Time)	After (Zero Time +3 sec)
Flaps	Full down (100%)	Full down (100%)
Nose-Fan Intake & Exit Doors	Open	Open
Wing-Fan Exit Louvers	45°	45°

The technique employed to satisfy the "before-conversion" condition of high J-85-5B RPM and low airspeed was initially to stabilize the aircraft in pre-conversion (PC) configuration at the desired airspeed (95 KIAS to 105 KIAS); this required approximately 88 percent to 92 percent of J-85-5B RPM. Immediately preceding selection of the fan-power mode switch, J-85-5B RPM was advanced to the desired magnitude (97 percent - 100 percent). Aircraft airspeed accelerations prior to conversion were between 1 KIAS and 5 KIAS, depending upon pilot quickness in performing these tasks. To correct this shortcoming, it is recommended that follow-on XV-5 aircraft be provided with speed brakes to assist the pilot during this phase of the conversion. The optimum conventional-to-fan-powered-flight conversion, of those conversions observed, was accomplished under the conditions noted in Table 4:

TABLE 4

	Before (Zero Time)	After (Zero Time +3 sec)
J-85-5B RPM	98%	100% +
Wing-Fan RPM	0%	100% +
Nose-Fan RPM	0%	100% +
Horizontal Stabilizer	-5°	+10°
Angle of Attack	+15°	0°
Airspeed	95 KIAS	85 KIAS
Density Altitude*	5000 ft	5000 ft

\* Conversions at higher density altitudes produced sink rates following conversions.

A pilot opinion rating of 2-1/2 was assigned to the conventional-to-fan-powered-flight conversion characteristics observed during this evaluation.

(2) A pilot opinion rating of 2 was assigned to the fan-powered-to-conventional-flight conversion characteristics observed during this evaluation. Wings level conversions were conducted both in level flight and during descents at airspeeds between 85 KIAS and 95 KIAS. All conversions were characterized by immediate acceleration and mild pitch-up that could be arrested with a 10 percent J-85-5B power reduction (100 percent to 90 percent). No specific control movement, other than throttle reduction, was required to maintain flight attitude following the conversion. The sensation of immediate acceleration was the most prominent "cockpit cue" of the conversion. Additional cues were: horizontal stabilizer visual and aural signals denoting the programmed movement of the stabilizer to the -5 degree leading edge down position, the visual signal's denoting diverter valve in the conventionally powered position and the decreased cockpit noise level. Total time required for the conversion was approximately 1 second. These conversion characteristics, as observed during this evaluation, enhanced the flying qualities of the XV-5A.

#### k. Longitudinal Flying Qualities:

(1) The major findings of the longitudinal flying qualities investigation were as follows:

(a) Undesirable longitudinal trimmability characteristics during both conventional and fan-powered flight (Paragraphs 9.k.(2), 9.k.(3)).

(b) Apparent negative stick-free and stick-fixed longitudinal static stability characteristics exhibited in fan-powered flight (Paragraph 9.k(4)).

(c) Characteristic shallow positive stick force gradients and large trim bands about trim airspeeds in PC configuration (Paragraph 9.k(5)).

(d) Heavy longitudinal damping characteristics exhibited in both fan-powered and conventional flight (Paragraph 9.k(7)).

A pilot opinion rating of 2-1/2 was assigned to the longitudinal flying qualities of the XV-5A observed under the flight conditions noted in Table 5:

TABLE 5

Configuration*	Pressure Altitude ft	Range of Airspeeds Tested KCAS
FP**	5000	30 - 70
PC	5000	100 - 150
CR	7500	150 - 250

\* See Inclosure 7.

\*\* Flight duration in FP configuration limited to 10 minutes due to structural heating limitation.

(2) During fan-powered flight insufficient longitudinal trim authority was available to permit trimmed flight at airspeeds between 35 KIAS and 55 KIAS for zero degrees angle of attack. This result was objectionable and detracted from the suitability of the XV-5A to perform its primary research mission. Correction of this shortcoming is desirable for follow-on XV-5 aircraft.

(3) The .2-degrees-per-second horizontal stabilizer trim rate during conventional flight was too slow at airspeeds less than 150 KIAS. The previous .4-degrees-per-second trim rate observed during the early portion of the evaluation was too fast at airspeeds in excess of 250 KIAS. To correct this shortcoming it is recommended that a compromise trim rate of .3 degrees per second be installed for evaluation.

(4) Apparent negative stick-free and stick-fixed longitudinal static stability characteristics were exhibited during fan-powered flight. Typical results of this portion of the stick-free evaluation are shown in Figure 2.

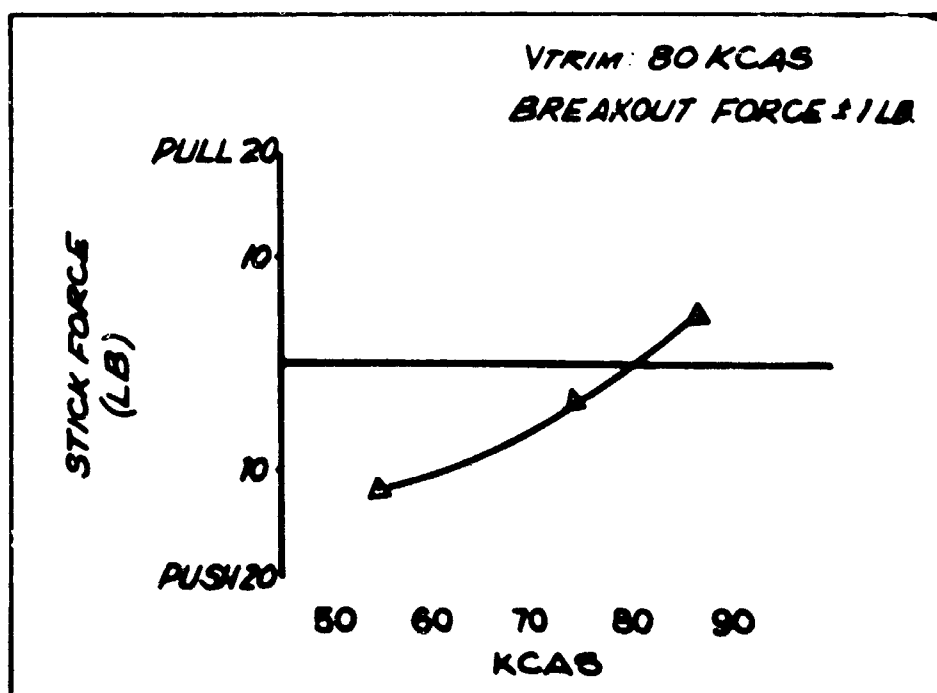


Figure 2

Due to the insufficient longitudinal trim authority (Paragraph 9.k(2)), "stick feel" was not the prominent factor to the pilot for airspeed control during fan-powered flight. Airspeed control in fan-powered flight was achieved primarily by pilot attention to flight instrumentation.

(5) Shallow positive stick force gradients and large trim bands about trim airspeeds described the typical longitudinal static stability characteristics in PC configuration. Landing gear position had negligible effect on the longitudinal stability characteristics. Typical results of this portion of the evaluation are shown in Figure 3.

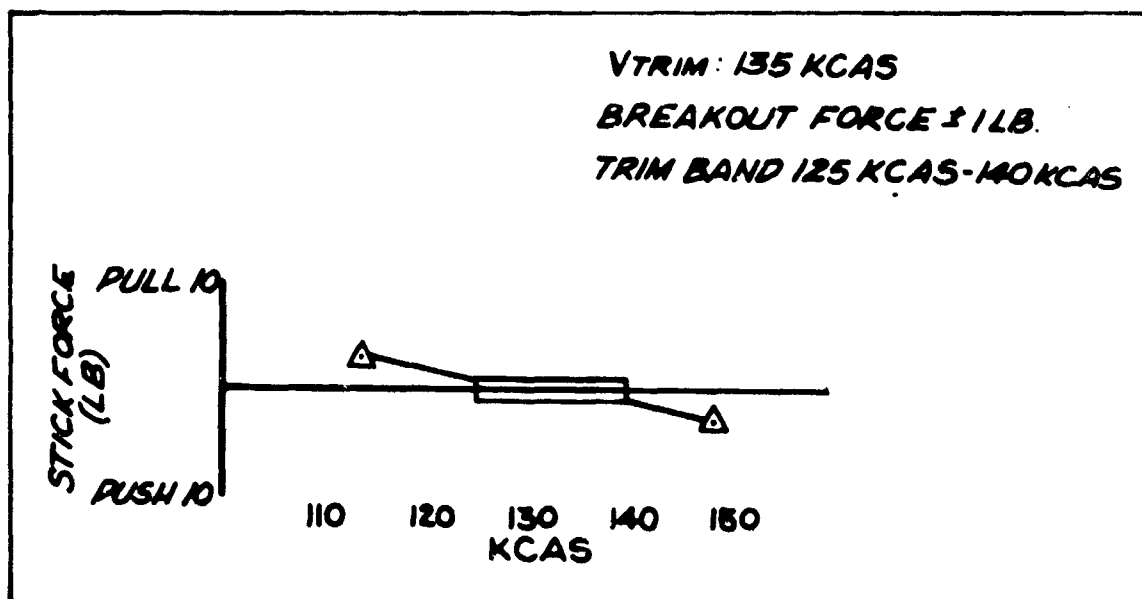


Figure 3

These results were not objectionable and provided satisfactory speed control characteristics under test conditions. Any further XV-5A testing of this nature should include similar tests conducted in "rough" air.

(6) An investigation of the longitudinal trim changes following a configuration change yielded the results shown in Table 6:

Table 6

Trim Conditions				Test		Results		
Trim A/S KIAS	Hor Stab deg	Flap %	Louver Gear	Power	Change	Parameter field c	*Stick Force	**Hor Stab deg
130	-2.5	0	Conv Up	PFLF	Gear Down	11p	8-lb Pull	-3.5
130	-3.5	0	Conv Up	PFLF	Flap Down 100%	11p	14-lb Pull	-5
130	-5	100	Conv Down	PFLF	Idle Power	Airspeed	10-lb Pull	-5
130	-2.5	0	Conv Up	PFLF	PC Conf	11p	14-lb Pull	-5
110	-5	100	Fan Up	PFLF	CR Conf	11p	14-lb Push	-3.5
110	-5	100	Conv Up	PFLF	Louver to Fan	11p	4-lb Push	Zero

\* Maximum stick force required to meet test conditions during 5-second period following configuration change.

\*\* Horizontal stabilizer position to re-trim aircraft 5 seconds after configuration change (-5 degrees horizontal stabilizer maximum trim available, aircraft nose up).

No objectionable flight characteristics were observed during these tests. These results enhanced the longitudinal flying qualities of the XV-5A.

(7) Results of a limited dynamic longitudinal stability investigation of the test aircraft in fan-powered flight and conventional flight (PC and cruise (CR) configurations) showed the longitudinal damping to be heavy in both configurations tested. At 250 KIAS in CR configuration the short-period mode was deadbeat. The short-period mode oscillation was observed to be heavily damped in both PC configuration at 130 KIAS and FP configuration at 40 KIAS. No objectionable flight attitudes were observed during any portion of this phase of the evaluation.

(8) The results of an effectiveness evaluation of horizontal stabilizer movement in PC configuration are shown in Table 7:

TABLE 7

5300 FT H <sub>P</sub> : 140 KIAS	
Horizontal Stabilizer deg	Longitudinal Stick Force
-5	5-lb push
-3	0-lb
-2	5-lb pull
-1	10-lb pull
0	15-lb pull
1	30-lb pull

These results showed the horizontal stabilizer to be a very effective longitudinal trim control. In the event of a runaway stabilizer at the recommended trim rate of .3 degrees per second (Paragraph 9.k(3)), the pilot would have ample time to initiate corrective action prior to the out-of-trim stick forces' becoming intolerable. These results enhanced the longitudinal flying qualities of the XV-5A.

#### 1. Lateral-Directional Flying Qualities:

(1) The major findings of the lateral-directional flying qualities were as follows:

(a) Positive directional stability and positive dihedral effect characteristics (Paragraphs 9.l(2), (4)).

(b) Apparent performance increase during steady-heading sideslips in FP configuration (Paragraph 9.1(3)).

(c) High rudder effectiveness as a secondary lateral control (Paragraph 9.1(5)).

(d) High apparent lateral control effectiveness (Paragraph 9.1(6)).

(e) Lateral "gust sensitivity" in PC configuration at airspeeds greater than 140 KCAS (Paragraph 9.1(7)).

A pilot opinion rating of 3 was assigned to the lateral-directional flying qualities of the XV-5A observed under the flight conditions listed in Table 8:

TABLE 8

Configuration	Pressure Altitude ft	Range of Airspeeds Tested KCAS
FP*	5000	27 - 71
PC	5000	102 - 147
CR	7500	148 - 325

\* Flight duration in FP configuration limited to 10 minutes due to structural heating limitation.

(2) Steady-heading sideslips in FP configuration exhibited positive directional stability and positive dihedral effect. Control inputs, characterized by light forces at the lower airspeeds, were symmetric to the pilot. Typical results of this portion of the evaluation, for the extreme trim airspeeds investigated, are shown in Table 9:

TABLE 9

FP CONFIGURATION 5300 FT H <sub>0</sub> : 240.0 IN C.G. 0-DEG ANGLE OF ATTACK										
A/S	6 Deg	Left (Lt)		Sideslip		6 Deg	Right (Rt)		Sideslip	
KCAS	Bank lt	Rudder Pedal		Control Stick		Rudder Pedal		Control Stick		Bank rt
		lb rt	in rt	lb lt	in lt	lb lt	in lt	lb rt	in rt	
27	1	5	.5	1	.8	5	.5	1	.6	1
71	5	25	1.5	1	1.2	40	2.5	1	2.0	5

As might be expected, in view of these results, steady-state sideslips were difficult to maintain at the lower trim airspeeds in FP configuration (<60 KCAS). At these airspeeds the aircraft tended to yaw indiscriminately about the desired sideslip angles, and this characteristic became more prominent as airspeed was reduced. These results were more of a nuisance-type shortcoming than objectionable in the accomplishment of the aircraft's primary mission. It was envisioned that at low airspeeds in FP configuration the aircraft would be in close proximity to the ground where sufficient visual ground cues would be provided the pilot to preclude inadvertent sideslips.

(3) An interesting phenomenon, the cause of which is not fully understood, was the apparent performance increase observed during sideslips in FP configuration. With no changes other than increased sideslip angle, the aircraft developed an increased rate of climb during steady-heading sideslips. This result will be investigated during the ensuing performance phase of XV-5A testing.

(4) In PC or CR configurations positive directional stability and positive dihedral effect were observed during steady-heading sideslips. Typical results of this portion of the evaluation at the extreme trim airspeeds investigated for each configuration are shown in Tables 10 and 11:

TABLE 10

PC CONFIGURATION 5000 FT H <sub>p</sub> , 242.9 FT C.G.										
A/S	6 Deg Left (Lt) Sideslip					6 Deg Right (Rt) Sideslip				
KCAS	Bank ° lt	Rudder Pedal		Control Stick		Rudder Pedal		Control Stick		Bank ° rt
		lb rt	in rt	lb lt	in lt	lb lt	in lt	lb rt	in rt	
102	5	35	1.8	1	1.4	25	2.0	1	1.4	5
147	9	65	2.0	2	1.0	65	2.0	1	1.0	5

TABLE 11

CR CONFIGURATION 7500 FT H <sub>p</sub> , 242.0 C.G.										
A/S	2 Deg Left (Lt) Sideslip					2 Deg Right (Rt) Sideslip				
KCAS	Bank ° lt	Rudder Pedal		Control Stick		Rudder Pedal		Control Stick		Bank ° rt
		lb rt	in rt	lb lt	in lt	lb lt	in lt	lb rt	in rt	
148	4	30	.4	2	.5	25	.5	1	.4	2
325	6	140	1.5	2	.2	100	1.4	1	.2	6

No undesirable flight characteristics were observed during this portion of the lateral-directional investigation. The apparent lack of harmony between lateral and directional control forces evidenced by the data shown in Tables 10 and 11 was not objectionable to the pilot. There did exist a nuisance-type tendency for the aircraft to wander in yaw ( $\pm 2$  degrees maximum) in PC configuration at airspeeds below approximately 110 KIAS. Above 110 KIAS the aircraft's "directional stiffness" increased with airspeed in both PC and CR configurations as evidenced by the 325 KCAS data of Table 11. These results enhanced the lateral-directional flying qualities of the XV-5A.

(5) At airspeeds greater than 40 KIAS the rudder served as an effective secondary lateral control in FP, PC and CR configurations. In CR configuration at 150 KIAS it was possible to negotiate 30-degree banked rudder "S" turns with no yawing tendencies. This result was desirable.

(6) No investigation of lateral control effectiveness was conducted in CR configuration during this evaluation. Qualitative results indicated that maximum roll rates in CR configuration would be pilot-limited rather than control-power-limited. The XV-5A appeared to have greater lateral control effectiveness than the previously evaluated Navy A4B, which developed roll rates in CR configuration at 250 KIAS in excess of 250 degrees per second.

(7) In PC configuration at 140 KCAS the aircraft tended to oscillate laterally after a wind gust disturbance. This oscillation was damped with airspeed reduction. To correct this shortcoming it is recommended that in follow-on XV-5A aircraft the full-flap extension limit speed be lowered from the present 180 KIAS to 140 KIAS.

m. Asymmetric Power Characteristics:

A limited evaluation of XV-5A's conventional flight asymmetric power characteristics was conducted during a trim climb at 140 KIAS. After a power advance to 98 percent (takeoff power) from trim power, the aircraft was allowed to accelerate to 160 KIAS. At 160 KIAS the right engine was reduced to idle. Stabilized indicated rates of climb were observed for airspeeds from 120 KIAS to 160 KIAS in the simulated "engine-out" condition. The results are presented in Table 12:

TABLE 12

Indicated Airspeed KIAS	Indicated Rate of Climb fpm
120	500
130	1000
140	1500
150	1500
160	1000

During this investigation approximately 5 pounds of left pedal force were required to maintain directionally trimmed flight. This small trim change was negligible. A pilot opinion rating of 2 was assigned to the conventional asymmetric power flying qualities observed during these tests.

n. Conventional Flight Stall Characteristics:

The following discussion is based upon the results of the contractor conducted flight. These results, in tabular form, are presented in Table 13:

TABLE 13

Configuration	Gross Weight/CG (lb/Station)	Buffet Onset deg	Stall (KIAS/ $\alpha$ ) deg	Recovery
PA	11,300/243.8	20	90/23.5	Immediate
PA	11,250/243.8	20	90/23	Immediate
PC (LG Down)	11,200/243.8	20	80/23	Immediate
PC (LG Up)	11,150/243.8	20	80/23	Post Stall Gyrations*

- \* Aircraft developed high sink rate with a slow pitch-up to a nose-high position. Pilot reported a lateral oscillation in nose-high position with no response to primary controls. Stall was recovered after a loss of approximately 7500 feet after lateral oscillation to the right caused nose to fall through. J-85-5B power was at or above 92 percent throughout the post stall gyration.

These limited results indicate that the power-on stall characteristics of the XV-5A include post stall gyrations. Any future investigation in this area should include the determination of the effectiveness of power reduction as a power-on stall recovery technique.

o. Emergency Operations:

The test aircraft was equipped with sufficient warning devices and redundant systems to enable the pilot to identify and

correct emergency situations. Conversions could be aborted at any time and the aircraft immediately returned to the configuration flown prior to the conversion initiation. Cockpit warning devices consisted of a 17-item standard annunciator panel with master caution light and the following warning lights:

Condition	Warning Device
Engine Fire and Compartment Overheat	(Visual)
Unsafe Landing Gear	(Visual and Aural)
Horizontal Stabilizer Movement	(Visual and Aural)
Unrequested Wing-Fan Louver Movement	(Visual)
Structural Overheat	(Visual)
Low Fuel Pressure	(Visual)
Low Fuel Quantity	(Visual)
Malfunctioning Electrical System	(Visual)

Dual hydraulic, stability augmentation and electrical systems were installed with a backup battery which would provide electrical power for approximately 5 minutes in the event both primary and secondary electrical systems failed. Two fire extinguishers were available for in-flight use on either engine compartment. A rocket-powered ejection seat was installed. The described emergency provisions were adequate for the safe conduct of this flight evaluation.

#### 10. CONCLUSIONS:

a. The flying qualities of the XV-5A observed during this evaluation are suitable to accomplish the primary mission of the aircraft.

b. Correction of the following deficiencies is mandatory for follow-on XV-5 aircraft:

- (1) Cockpit temperature control (Paragraph 9.b(1)).
- (2) Ground handling characteristics (Paragraph 9.d(1)).
- (3) Vertical takeoff and landing characteristics (Paragraphs 9.f(1), (2), (3)).
- (4) Ten-minute maximum flight duration limitation in FP configuration (Paragraph 9.i(4)).

(5) Wing lift-fan cavity heating characteristic (Paragraph 9.h(2)).

c. Correction of the following shortcomings is desirable for follow-on XV-5 aircraft:

(1) Cockpit switch and instrument locations (Paragraphs 9.b(2), (3), (4)).

(2) Cockpit downward and aft vision (Paragraphs 9.b(5)), 9.f(3)).

(3) Canopy release mechanism (Paragraph 9.b(6)).

(4) Absence of parking brake (Paragraph 9.d(2)).

(5) Conventional and vertical crosswind landing characteristics (Paragraphs 9.e(3), 9.f(3)).

(6) Engine overtemp characteristics (Paragraph 9.h(1)).

(7) Lift-fan air re-ingestion characteristics in close proximity to the ground (Paragraph 9.h(3)).

(8) Lift-fan overspeed characteristics (Paragraph 9.i(1)).

(9) Lack of speed brakes (Paragraph 9.j(1)).

(10) Longitudinal trimmability characteristics during conventional and fan-powered flight (Paragraphs 9.k(2), 9.k(3)).

(11) Lateral "gust sensitivity" in PC configuration (Paragraph 9.l(7)).

d. An overall pilot opinion rating of 4 was assigned to the flying qualities of the XV-5A aircraft observed during this evaluation.

#### 11. RECOMMENDATIONS:

a. Correction of the deficiencies listed in Paragraph 10.b be accomplished on a mandatory basis on follow-on XV-5 aircraft.

b. Correction of the shortcomings listed in Paragraph 10.c be accomplished on a priority basis on follow-on XV-5 aircraft.

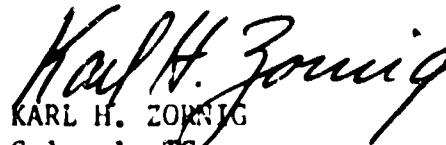
c. Variable SAS be retained on follow-on XV-5 aircraft for SAS optimization (Paragraph 9.g).

d. Full (100 percent) flap extension maximum airspeed limit be reduced to 140 KIAS (Paragraph 8.1(7)).

e. Set horizontal stabilizer longitudinal trim rate at .3 degrees per second (Paragraph 9.k(3)).

9 Incl

1. Char of XV-5A
2. Control Sys
3. Test Instr
4. GW and CG Info
5. Pert Flt and Op Limit
6. Instr Presentation
7. Test Config
8. Indiv Pilot Part
9. Pilot Opinion Ratings

  
KARL H. ZORNIG  
Colonel, TC  
Commanding

Copies furnished:

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DDC (20)

# CHARACTERISTICS OF THE XV-5A AIRCRAFT

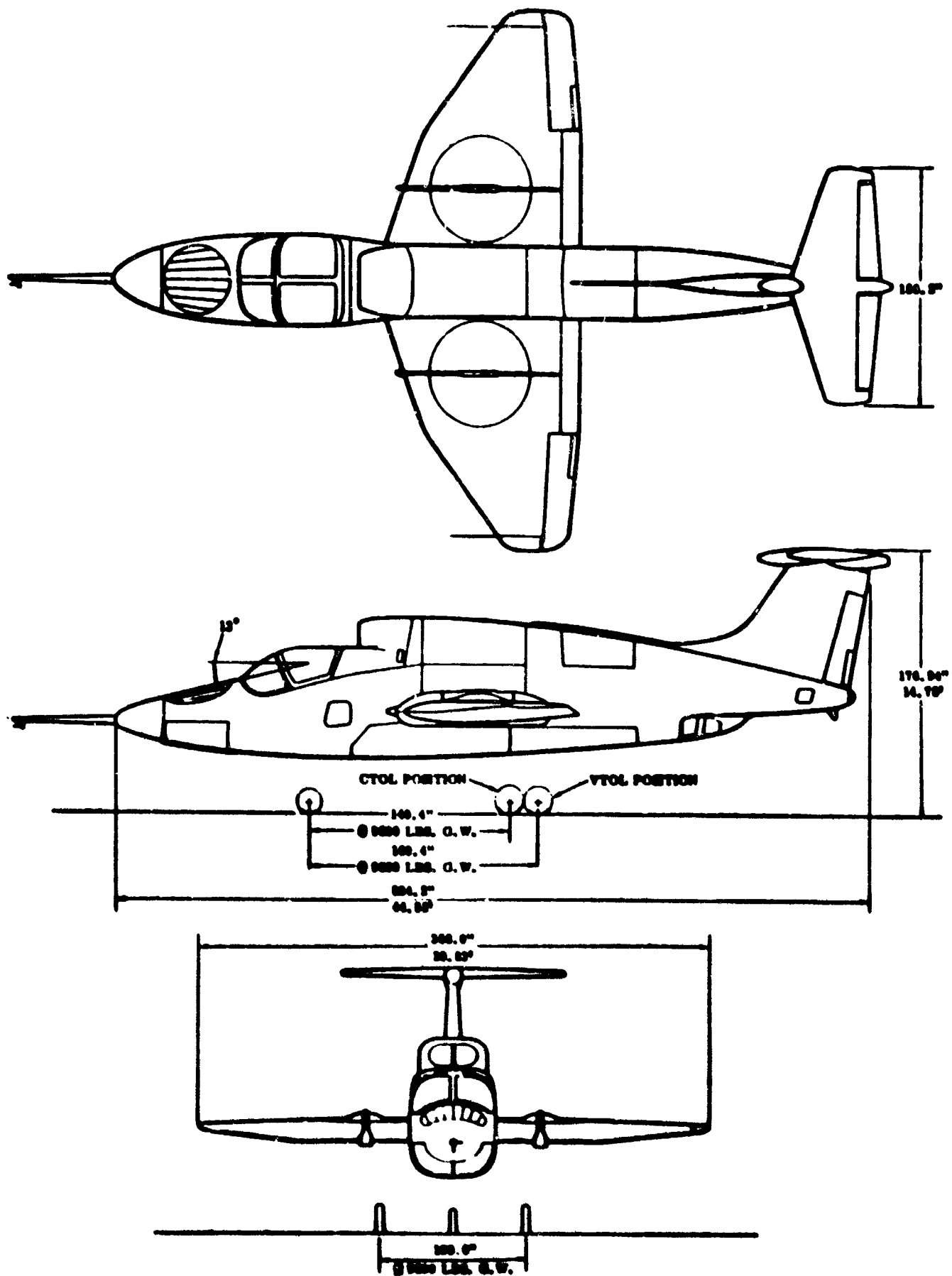


Figure 1 Three View Drawing

## CHARACTERISTICS OF THE XV-5A AIRCRAFT

### 1. MAXIMUM CONTROL MOVEMENTS:

a. Rudder	25 deg lt and rt
b. Rudder Pedals	3.25 in fwd and aft
c. Rudder Trim Tab	10 deg lt and rt
d. Elevator	25 deg up and down
e. Longitudinal Control Stick	6 in fwd and aft
f. Ailerons	19 deg up (flap at 0 deg) 15 deg down (flap at 0 deg) 23 deg up (droop at 15 deg) 12 deg down (droop at 15 deg)
g. Lateral Control Stick	4 in lt and rt
h. Aileron Trim Tab (Right Side)	27 deg up 18 deg down
i. Aileron Trim Tab (Left Side)	30 deg up 21 deg down
j. Horizontal Stabilizer	20 deg leading edge up 5 deg leading edge down
k. Wing Flap	45 deg down
l. Wing-Fan Louver Angle (BV)	-7 deg down
m. Nose-Fan Thrust Control Door Deflection (From Full-Down Position)	68 deg

### 2. DIMENSIONS AND GENERAL DATA:

a. Wings:	
(1) Span	29.8 ft
(2) Mean Aerodynamic Chord	112.9 in

- |                                  |  |
|----------------------------------|--|
| (3) Airfoil Section              | NACA 0012-64   |
| (4) Sweep                        | 15.5 deg (inboard)   |
| (5) Dihedral                     | 28.3 deg (outboard)<br>0 deg (inboard)<br>4.0 deg (outboard) |
| (6) Aspect Ratio                 | 3.4  |
| <b>b. Ailerons:</b>              |  |
| (1) Hinge Line Span              | 75.5 in  |
| (2) Average Chord                | 32.7% Wing Chord   |
| (3) Trim Tab Span                | 28.0 in  |
| <b>c. Flaps:</b>                 |  |
| (1) Type                         | Single Slotted   |
| (2) Span                         | 43% Wing Span  |
| <b>d. Horizontal Stabilizer:</b> |  |
| (1) Span                         | 13.2 ft  |
| (2) Airfoil Section              | NACA 64A012  |
| (3) Aspect Ratio                 | 3.3  |
| <b>e. Elevators:</b>             |  |
| (1) Span                         | 5.5 ft per side  |
| (2) Root Chord                   | 16.0 in  |
| (3) Tip Chord                    | 10.2 in  |
| <b>f. Rudder:</b>                |  |
| (1) Span                         | 5.2 ft (parallel to hinge line)                              |
| (2) Root Chord                   | 18.0 in aft of hinge line and perpendicular                  |

**g. Wheel and Tire Size:**

- |                 |                           |
|-----------------|---------------------------|
| (1) Main Wheels | 20 x 4.4 - 12 PR Type VII |
| (2) Nose Wheel  | 18 x 4.4 - 10 PR Type VII |

**h. Tread of Main Wheels:**

(Static Standing at 9200 lbs GW)	100.6 in
-------------------------------------	----------

## CONTROL SYSTEMS

### 1. GENERAL

The XV-5A aircraft has two basic primary flight control systems, the fan-powered control system and the conventional control system. Except for the lift control of the fan-powered system, both control systems are operated from common cockpit controls and linkage to common junctures within the fuselage. From these control junctures the linkage is branched off as required to serve either fan-powered or conventional-system functions. The conventional surfaces (elevator, rudder and ailerons) are operable at all times; the fan-powered output controls are electromechanically made ineffective during transition to conventional flight.

### FAN-POWERED CONTROL SYSTEM\*

#### 2. GENERAL

The fan-powered primary control system is a fully powered irreversible system. Pilot commands at the conventional stick, lift stick and control pedals are applied through mechanical linkage to second-stage spools of integral hydraulic servo valve actuators. These actuators, two located in each wing and one located in the nose of the aircraft, position exit louvers located on the underside of each wing and exit doors on the underside of the nose section. They modulate high-velocity exit gases both in terms of force magnitude and direction.

#### 3. FAN-POWERED UTILITY CONTROLS

To accomplish fan-powered flight, the following utility and subsystems are installed:

a. Wing Inlet Door Actuators and Latches - A pair of butterfly-type inlet doors are located on the upper surface of each wing to provide the wing-fan air-inflow path. Both wing sets are simultaneously fully opened or closed by means of a cluster of four linear hydraulic actuators mounted underneath the doors in each wing. Command signal is provided from the pilot's mode selector switch to dual four-way solenoid control valves. Prior to door opening, the signal from the cockpit flap "down" switch causes an electrically operated latch on each door to release. Cockpit indicator lights are provided for indication of full-locked or full-released position.

\*See Figure 1, page 6.

Additional sequence limit switches are installed on the inlet doors so that when they reach optimum position on opening, the diverter valve actuator is set up for actuation.

b. Pitch-Fan Inlet Louvers - The pitch-fan inlet louvers, located at Station 59 on the top nose surface of the aircraft, provide the pitch-fan air-inflow path. They are controlled by means of two electrical actuators, mounted within the airframe, one on each side. Each actuator operates a cluster of mechanically linked louvers to the full-open or closed position. The actuators are electrically wired in such a way that both units must actuate limit switches on full opening prior to any further sequence action in conversion to fan-powered mode. Actuation is initiated through the flap switch. Visual operational check is made by the pilot.

#### 4. WING EXIT LOUVER CONTROL

a. The main linkage component between the pilot controls and the wing servos is the mechanical mixer assembly located on the aft side of the center section of the forward wing spar. This assembly sums up independent pilot mechanical commands of roll, yaw, and lift and electrical commands of thrust vectoring. Output displacements of the assembly are fed through push-pull rods to fore and aft torque tubes located spanwise in each wing. Each torque tube is subsequently linked to a servo valve actuator.

b. To provide artificial pilot feel during hovering, the mixer contains feel springs in the roll and yaw modes. In conjunction with these spring packages, roll and yaw electrical trim actuators are provided. Each trim actuator aligns the spring package zero force position with the pilot's stick or pedal position, thereby relieving the force at the stick or pedals, respectively. This trim capability is approximately 15 to 20 percent of the full stick or pedal authority.

#### 5. PITCH FAN EXIT-DOOR CONTROL

a. The main linkage component between the pilot controls and the pitch-fan exit-door servo is the pitch mixer assembly located centrally in the fuselage underneath the electrical compartment at Station 142 to Station 154. This assembly sums up independent mechanical inputs of pitch and lift control. Output displacements of the pitch mixer are fed through push rods to the nose exit-door servo, located approximately at fuselage Station 91.00.

b. To provide artificial pilot feel for pitch during hovering, the mixer contains a feel spring package. In conjunction, an electrical pitch trim actuator is provided to align the spring package zero position with the pilot's conventional (pitch) stick within the trim band. The actuator also has a linear pot for position readout on the instrument panel. Limit switches are also installed for integrator cutout of the pitch stability augmentation channel when large pitch commands are made.

#### 6. LIFT STICK CONTROL

The pilot's lift stick is mechanically linked to both mixers to apply pilot lift commands simultaneously to wing exit louvers and pitch-fan exit doors. The collective stick has no direct linkage connection to the conventional system. During transition to conventional flight its output linkage to the pitch and mechanical mixer is made ineffective by the interconnect cable to the thrust vector actuator and the cam and override spring arrangement in the mechanical mixer.

#### 7. STABILITY AUGMENTATION SYSTEM

In conjunction with the fan-powered control system, a stability augmentation system (SAS) provides rate of attitude stabilization of the aircraft. This system is parallel with the manual servo system in such a manner that automatic stability electrical inputs to a first-stage flapper motor add to or subtract from the manual inputs at the second-stage spool of each servo valve. The SAS has essentially 25 percent of the overall mechanical authority in roll, yaw, and pitch available at 0 degrees Bv and thus can always be manually overridden either by the manual input to the servo valves alone or by its combined effect with the conventional surface deflection at other Bv conditions. Limit switches are provided on the pilot's controls to cut out automatically the integrator (position reference) of the SAS when large roll, yaw, or pitch commands are made. The rate signal of the SAS is always in effect. The SAS control amplifier assembly is located in the electrical compartment aft of the pilot's compartment (Station 150 approximately).

### CONVERSION ACTUATORS

#### 8. DIVERTER VALVE ACTUATORS

In conversion, two diverter valve actuators are provided for diverting the engine jets fully aft through twin tail pipes (conventional flight) or fully through cross-over ducts to drive the wing and nose fans (fan-powered flight). The diverter valves are

mechanically coupled between the engines to synchronize their operation. Cockpit indicator lights are provided to indicate satisfactory diverter valve action. The diverter valve actuators and indicator light switches are customer-furnished and installed power plant equipment.

#### 9. HORIZONTAL STABILIZER ACTUATORS

The horizontal stabilizer is actuated by means of two hydraulic motors, driving an integral self-locking screw jack. Each motor is operated from one of the primary hydraulic systems through control valves, bypass valves and flow restrictors. In conversion from fan-powered to conventional flight or vice versa, the stabilizer is automatically programmed at its maximum rate to a predetermined optimum angle for either mode of flight. Limit switches at this point actuate the motor control valves to closed position, stopping the stabilizer and de-activating the automatic conversion programming. Thereafter, the pilot may trim the stabilizer in conventional mode to any desired pitch trim angle at a rate established by the flow restrictors and bypass valves for that mode of flight. In fan-powered flight, the stabilizer is automatically maintained at 20 degrees leading edge up through a vertical takeoff and landing (VTOL) range of -5 degrees Bv to +30 degrees Bv. Between 30 to 40 degrees Bv, it may be trimmed by the pilot at VTOL trim rates to establish longitudinal trim prior to conversion to conventional takeoff and landing (CTOL). During conversion to CTOL, the stabilizer is automatically programmed at its maximum rate to -5 degrees leading edge down. Subsequent to conversion, it may be trimmed by the pilot to desired trim angles at established CTOL trim rate. In conversion from CTOL to VTOL, the stabilizer is automatically programmed to +10 degrees leading edge up. At 30 degrees Bv it is further automatically programmed to 20 degrees leading edge up where it remains in VTOL mode as mentioned above.

#### CONVENTIONAL CONTROL SYSTEM

#### 10. GENERAL

The conventional primary flight control system is a Type I reversible mechanical system for elevator and rudder operation and a Type II power boost reversible system for aileron operation. Pilot commands at the conventional stick and control pedals are applied through mechanical linkages and control rods common to both the fan-powered and conventional systems. At the points of juncture (wherefrom each primary system has independent mode linkage) the rudder and elevator modes of the conventional system essentially become cable-pulley systems back to their respective control surface horns. Tension regulators are installed to minimize the effects of flight structural

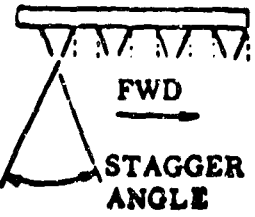

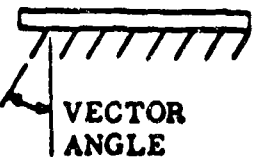



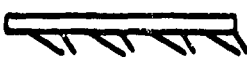



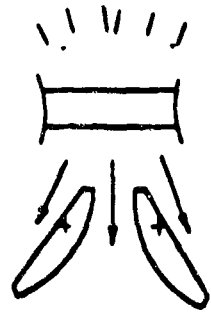


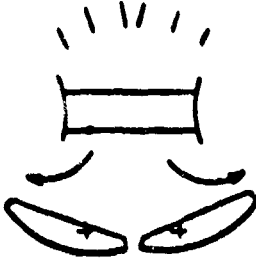
deflections and thermal expansions. The conventional roll mode linkage, from its point of juncture with the fan-powered roll mode linkage, continues as a push-pull rod system. It is directly linked through the droop mechanism to the aileron servo tab and control valve of the aileron boost actuator in each wing.

#### 11. AILERON DROOP MECHANISM

The aileron droop mechanism, located in the fuselage at Station 188.9, transmits proportional aileron droop as a function of flap deflection to provide additional conventional-flight lift. An electrical screw jack actuator, receiving the same pilot signal as that sent to the flap actuator, subsequently drives the ailerons to the desired droop angle (15 degrees maximum). Terminal limit switches are provided for its operation. Under normal roll command, pilot input is fed directly through the droop mechanism linkage to provide opposite push-rod motion to the ailerons. The mechanism also acts as the juncture point for fan-powered roll linkage to the mechanical mixer.

#### 12. SECONDARY CONTROL TRIM ACTUATORS

Conventional roll trim is provided in the left wing only by means of an electrical trim actuator driving the servo tab. Conventional pitch trim is achieved through the horizontal stabilizer as discussed in Paragraph 9. Conventional yaw trim is achieved through the electrical trim actuator driving the rudder trim tab. Roll, yaw and pitch trim indications are read out on the pilot's CTOL trim indicator.

RIGHT FAN	LEFT FAN	NOSE FAN	FUNCTION
			LIFT - COLLECTIVE STAGGER
			ACCELERATION CONTROL - COLLECTIVE VECTOR
			DIRECTIONAL TRIM & CONTROL - DIFFERENTIAL VECTURING
			LATERAL TRIM AND CONTROL - DIFFERENTIAL STAGGER
			PITCH TRIM AND CONTROL (NOSE UP)
			PITCH TRIM AND CONTROL (NOSE DOWN)

**Figure 1**  
**Fan-Power Flight Control System Operation**

## TEST INSTRUMENTATION

### 1. COCKPIT:

- a. Sensitive High Airspeed Indicator
- b. Sensitive Low Airspeed Indicator
- c. Standard Calibrated Altimeter
- d. Sensitive Angle of Attitude Indicator
- e. Sensitive Sideslip Angle Indicator

### 2. PULSE CODE MODULATOR PARAMETERS:

- a. Pitch Fan Exit-Door Position
- b. Lateral Stick Position
- c. Longitudinal Stick Position
- d. Rudder Pedal Position
- e. Rudder Position
- f. Pitch Fan RPM
- g. Pitch Attitude
- h. Roll Attitude
- i. Pitch Rate
- j. Roll Rate
- k. Altitude
- l. Angle of Attack
- m. Angle of Sideslip
- n. Elevator Position
- o. Airspeed
- p. Left-Hand Exhaust Gas Temperature
- q. Right-Hand Exhaust Gas Temperature
- r. Left-Hand Fuel Flow
- s. Right-Hand Flap
- t. Right-Hand Fuel Flow
- u. Left Hand Engine RPM
- v. Right-Hand Engine RPM
- w. Yaw Rate
- x. Lateral Center-of-Gravity Accelerometer
- y. Longitudinal Center-of-Gravity Accelerometer
- z. Vertical Center-of-Gravity Accelerometer
- aa. Left-Hand Wing Fan RPM
- bb. Right-Hand Wing Fan RPM
- cc. Left-Hand Aileron Position
- dd. Collective Position
- ee. Horizontal Stabilizer Position
- ff. Vector Angle Command
- gg. Outside Air Temperature

3. TELEMETER PARAMETERS:

- a. Angle of Attack
- b. Longitudinal Stick Position
- c. Right Vane Forward Stress
- d. Left Vane Forward Stress
- e. Right Vane Aft Stress
- f. Left Strut Stress
- g. Right Strut Stress

4. ANALOG TAPE PARAMETERS:

- a. Rudder Pedal Position
- b. Longitudinal Stick Position
- c. Lateral Stick Position

# GROSS WEIGHT AND CENTER-OF-GRAVITY INFORMATION

Gross Weight Conditions*		Center of Gravity	
Configuration	Weight	Horizontal Arm	Mean Aerodynamic Chord
	lb	in	%
Weight Empty	8,081	248.4	33.0
Design Gross Weight	9,200	240.8	26.3
Extended Range (Less Instrumentation	12,500	246.0	30.9

\*NOTE: All conditions include 515 pounds of standard equipment unless otherwise noted.

All conditions are with the landing gear retracted.  
Forward Center-of-Gravity Limit - Station 240, 25.6% MAC. Aft Center-of-Gravity Limit - Station 246, 30.87% MAC.

PERTINENT FLIGHT AND OPERATING LIMITATIONS\*

1. FAN OPERATING LIMITS

- a. Minimum Gas Generator RPM for Fan Mode Operation 70% Min
- b. X353-5B Wing Fans
  - (1) Fan Speed 103% Max
  - (2) Fan Cavity Temperatures 120°C Max
- c. X376A - Pitch Fan
  - (1) Fan Speed 110% Max
  - (2) Fan Cavity Temperatures 120°C Max

2. AIRSPPEED LIMITATIONS

Conventional Flight

- (1)  $V_{max}$  406 KIAS Max
- (2) Low Airspeed Indicator 150 KIAS
- (3) Landing Gear and Flaps Extended 180 KIAS
- (4) Landing Gear Retraction/Extension 180 KIAS
- (5) Flap Retraction/Extension 180 KIAS

3. PROHIBITED MANEUVERS

- a. Flight at Angles of Attack in Excess of +15 deg
- b. Intentional Spins and Stalls
- c. Inverted Flight
- d. 360-deg Aileron Rolls

4. FLIGHT DURATION

Fan-Powered Flight

W/Heat Shield and Fixed Landing Gear Down 10 Min

\*Additional limitations are contained in XV-5A handbook.

Inclosure 5

Page 1 of 3

5. ALTITUDE LIMITATIONS
- Conversions 5300 ft Hp Min
6. J-85 OPERATING LIMITS
- Maximum in Flight Exhaust Gas Temperature 680 deg C
7. CENTER-OF-GRAVITY LIMITATIONS
- Allowable Range 240.0 in to  
243.5 in
8. WIND LIMITATIONS
- a. All Flights 15 kt Max
- b. Vertical Takeoff and Hover Flights 6 kt Max
9. LANDING SINK RATES
- a. 10 ft/sec at 9200 lb GW
- b. 6 ft/sec at 12,500 lb GW
10. TAKEOFF GROSS WEIGHT
- a. Conventional Takeoff and Landing Mode 12,500 lb Max
- b. Vertical Takeoff and Landing See Figure 1

*MAXIMUM TAKE-OFF GROSS WEIGHT-FAN MODE*  
VERTICAL LIFT-OFF

MAX. POWER  
FULL UP COLLECTIVE  
2500 FT PRESSURE ALTITUDE

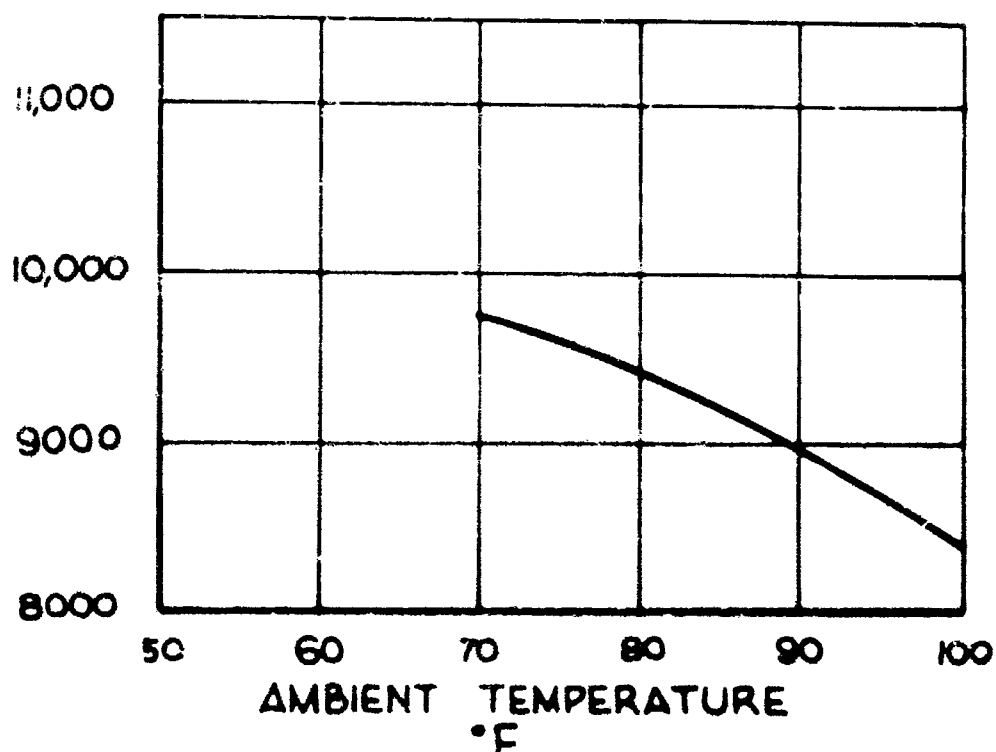
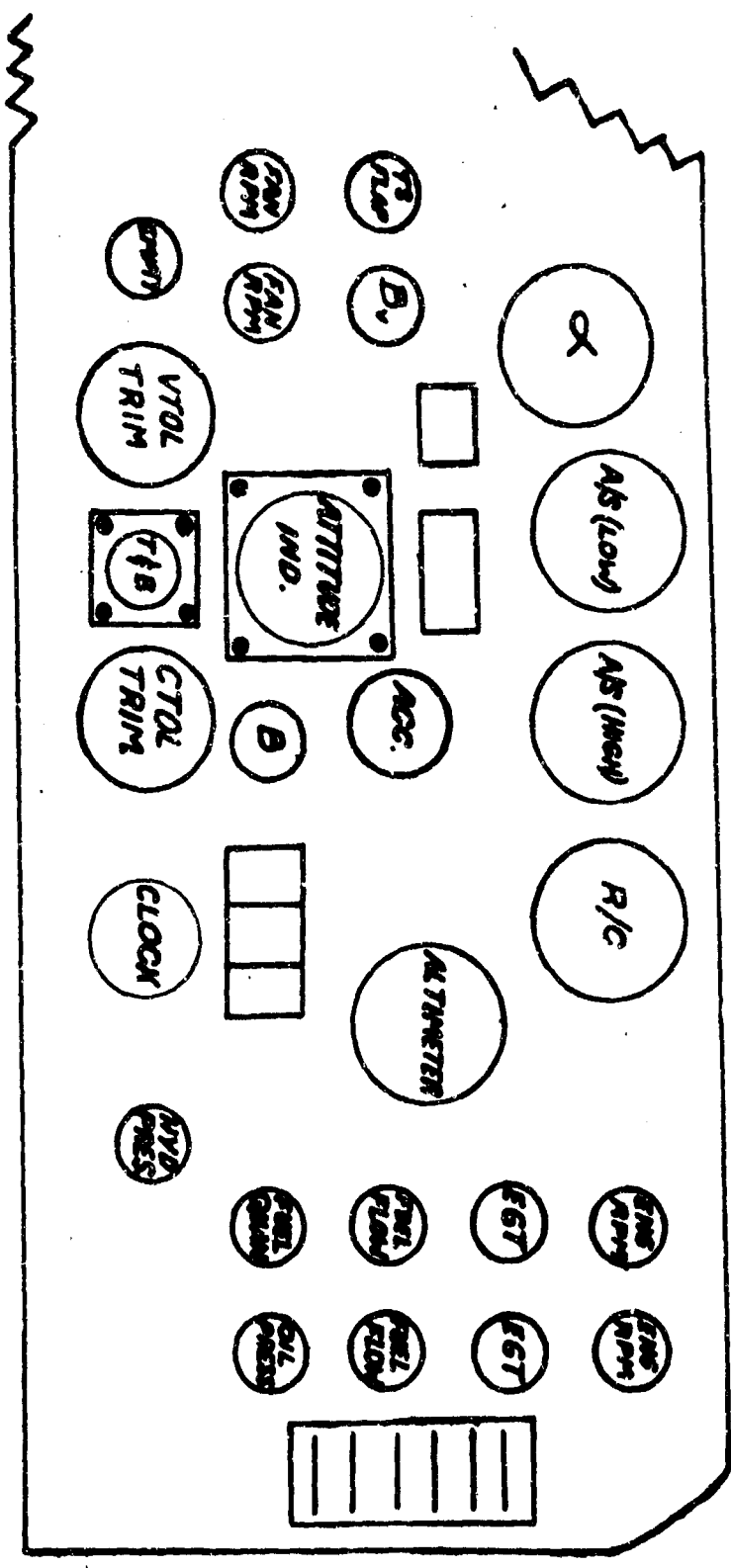


Figure 1  
Takeoff Gross Weight - Vertical Takeoff and Landing

Figure 1



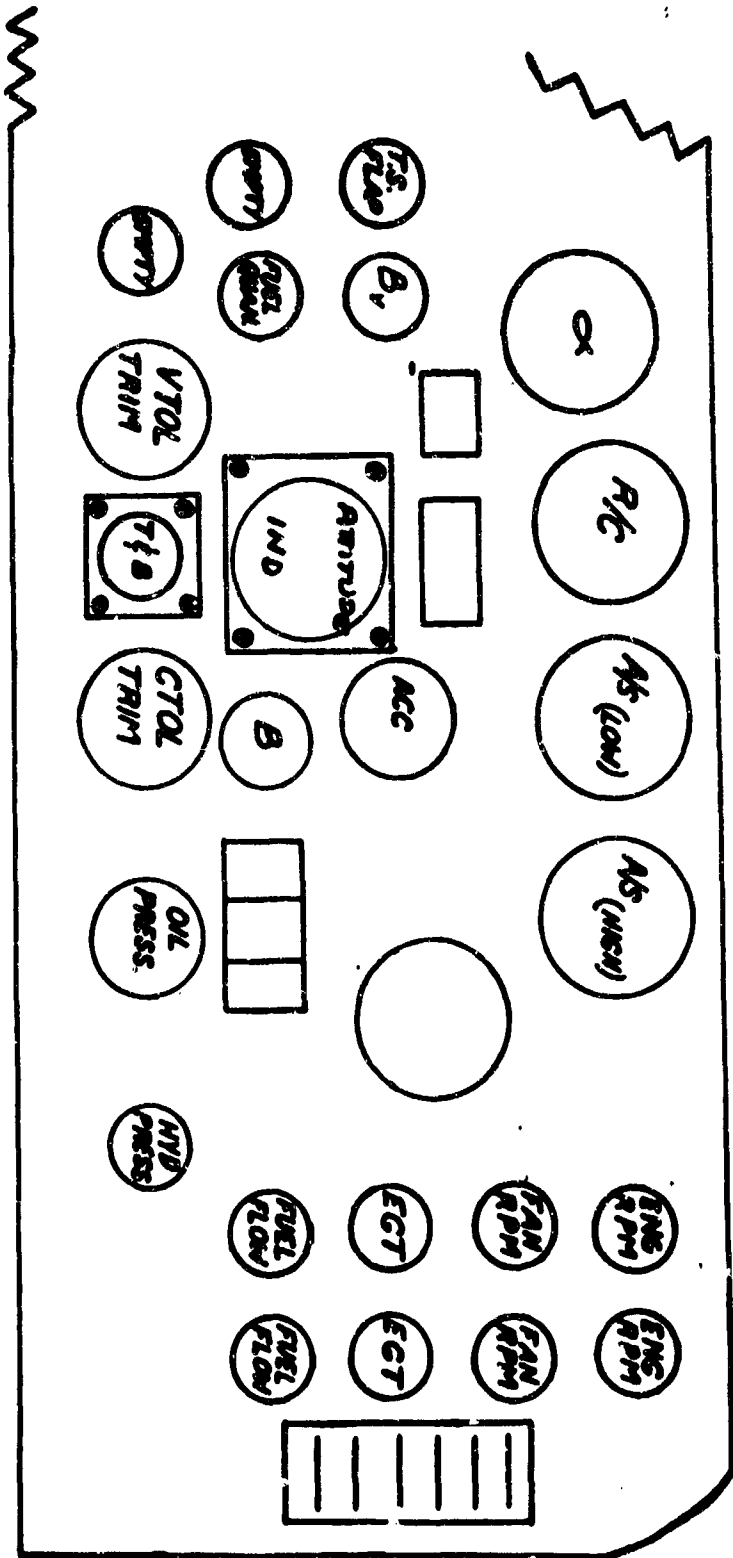
EXISTING INSTRUMENT PRESENTATION

# TEST CONFIGURATIONS

## POWER: Power for Level Flight

Configuration	Landing Gear	Flaps	Wing-Fan Doors	Wing-Fan Exit Louvers	Nose-Fan Intake and Exit Doors	Horizontal Stabilizer	Diverter Valve Position
Cruise (CR)	Up	Up	Closed and Locked	Closed	Closed	-2° to -5°	Conventional
Power Approach (PA)	Down	100%	Closed and Locked	Closed	Closed	-2° to -5°	Conventional
Pre-Conversion (PC)	Variable	100%	Closed and Locked	Open to 45°	Open	-2° to -5°	Conventional
Fan Power (FP)	Variable	100%	Open	Open to -7° to +45°	Open	+10° to +120°	Fan Power

Figure 2



SUGGESTED INSTRUMENT PRESENTATION

# INDIVIDUAL PILOT PARTICIPATION

Pilot/Unit	Flight Time hr/min	Conversions (V-C) (C-V)	
Anderson, W. A. Civilian, USAAVNTA	08:25	9	10
Curry, P. R. Major, USA, USAAVNMLABS	02:40	3	3
Welter, W. L. Captain, USA, USAAVNTA	13:10	15	16
TOTAL	24:15	27	29

# PILOT OPINION RATINGS

ADJECTIVE	DESCRIPTION	RATING
EXCELLENT	Includes optimum	1
VERY GOOD	No unpleasant characteristics; some nuisance-type deficiencies when no impairment to normal operation occurs.	2
GOOD	Some unpleasant characteristics in regimes where no impairment to normal operation occurs.	3
FAIR	Some unpleasant characteristics that cause perceptible fatigue; precision tasks possible after additional training.	4
POOR	Controllable but fatiguing; precision tasks possible but difficult even after extensive training.	5
POOR to BAD	Controllable for short periods only without excessive fatigue; precision tasks questionable even after extensive training.	6
BAD	Total pilot attention required just to operate aircraft; precision tasks impossible.	7
DANGEROUS	Almost uncontrollable; accident probable.	8
CATASTROPHIC	No control; accident certain, escape questionable.	9

Inclosure 9

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